The Method of Graphic Abstraction in Visual Metaphor

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Abstract

In the design fields, graphics are often a medium of communication whose goal is to reach mutual understanding. The process of graphic abstraction is one of the most important methods in visual design. Designers often use it to enhance the recognition and impression of observers. This paper investigated abstraction methods through design software research and research of designer practices. The result showed that the major tools used in designer practice are paintbrushes (traditional hand-drawing medium) and software filters (computer media). Three abstraction methods were identified: a) shape simplification method, b) quantitative reduction and c) software-aided simplification. Designers used software programs mainly for simplification of overall image (plane) with comparatively little use to simplify 'points' or 'lines.' In addition, the design software cannot fulfill designers' needs for visual abstraction. The findings from this study can provide valuable references for user instructions, graphic design and computer-aided design applications.

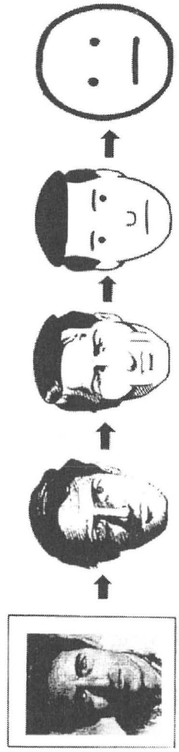

Figure 1 Five levels of 2D representation transferred from real object through graphic simplification (McCloud, 1994).

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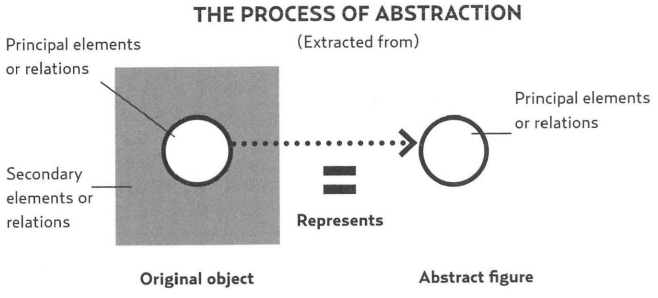
INTRODUCTION

To turn a real object (3D) into a 2D representation is an example of graphic-abstraction in visual design. (*see figure 1*; Arnheim, 1969; Langer, 1953; Yo, 1985; Hsu, 1993). The abstraction uses a strategy of simplification of detail, so designers often simplify the shape of the original object to enhance the recognition or impression of observers (Arnheim, 1969; Bell, 1913; Gombrich, 1982). Thus, abstraction is one of the most important methods in graphic design.

The function of graphics is to communicate messages efficiently and accurately in human life. As a result, the rational analysis of graphics and their uses might help to enhance that efficiency and accuracy. Although an analysis of rules in the field of graphic design seems more challenging than in the fields of architecture or industrial design, as far back as in the Renaissance, Leonardo **Da Vinci proposed that painting should be approached with a scientific aspect. Mistakes are likely to occur, he suggested, if structures and outlines are drawn from impression, rather than using the tools of measurement.**

Modern-design methodology attempts to scrutinize design scientifically. Although there are still gray areas in which science cannot give an account, the methodology has a significant bearing on user instructions (Burden, 1996; Jones, 1992; Munari, 1989). With the development of digital technology, the application of design methods can be transformed into the computation that has also presented itself as an important research topic (Kirsch & Kirsch, 1988; Knight, 2003; Simon, 1981; Stiny & Mitchell, 1978). Therefore, discovery of the 'methods' behind design is beneficial to both user instruction and design computation.

Figure 2 Abstraction process model.



RESEARCH FRAMEWORK

This research is a case study that explores graphic abstraction in digital and traditional media.

This paper investigates abstraction methods through design software research and design practice research. First, in order to reflect the trend that modern design depends heavily on software, software that serves abstraction functions was examined in the design-software research section. Four of designers' favorite software are analyzed: Adobe Illustrator 10, Adobe Photoshop 7, Macromedia Fireworks MX, Macromedia Flash MX. Second, to understand the work of designers currently using graphic-abstraction methods, thirty-two Shih-Chien University sophomore and junior students, equipped with design expertise, were surveyed with regard to their practice.

LITERATURE REVIEW

Abstraction process model

'Abstraction' is widely discussed in philosophy, science and psychiatry. The Gestalt School is the earliest school of art to systematically carry out this type of study. They presented the law of Pragnanz, which states that the best form is the form that has been 'appropriately simplified.' This is because people's visual perception leans towards using the most economical method to receive information (Arnheim 1969, 1974). Illustrated by 'the abstraction model' in Figure 2, this concept shows that the abstract figure (that contains principle elements extracted from the original object) is able to represent the original.

Hsu & Wang (2004) proposed a definition for abstraction in art and design. They suggested

Table 1 Research approaches to abstraction in art and design (adapted from Hsu & Wang, 2004).

Research approach	Description	Scholars	Examples of application
Internal cognitive mechanism	The reification of the abstract internal	Arnheim, 1969; Langer, 1953; Osborne, 1988; Worringer, 1953	Abstractionism
External visual simplification	The abstraction of the concrete physical	Arnheim, 1974; Goodman, 1976; Hsu, 1993; Lee, 2003; Osborne, 1979	Primitive arts

Note: The table does not suggest a dichotomous summary of the scholars' researches, but rather the general direction of their viewpoints.

that 'abstraction in art/design' can be divided into two research approaches: one from an internal cognitive mechanism and the other from external visual simplification (*see table 1*).

From the perspective of visual simplification, an abstraction model is shown as Figure 3. On the left is the entire body of Chaplin, whose most representative elements are the hat and the moustache. The body is second in importance to the head in representing Chaplin. On the right is the abstracted figure. Although several elements have been taken out, the connection between the highly simplified picture and Chaplin still exists.

This abstraction process model may not be clear or detailed enough to guide design operations, but it helps to explain the general principles of abstraction methods.

The following discussion and investigation will focus on the dimension of 'external visual simplification.'

Abstraction methods in design

Abstraction methods in design are different from those in artistic expressions. Gombrich (1982) suggested that designers often use abstraction to make graphics clearer and easier to recall. Therefore it is important for designers to distinguish different abstraction methods between the art and design professions. We suggest that designers pay more attention to recognizability by observers.

In Figures 4 and 5, the trademark adopted by North Sea Gas in Britain combines the trident of the mythical figure Nepture and a gas burner. The earlier trademark was designed on the basis of realistic illustration (*figure 4*) and the later design simplified and abstracted the elements, preserving only the essentials (*figure 5*, both

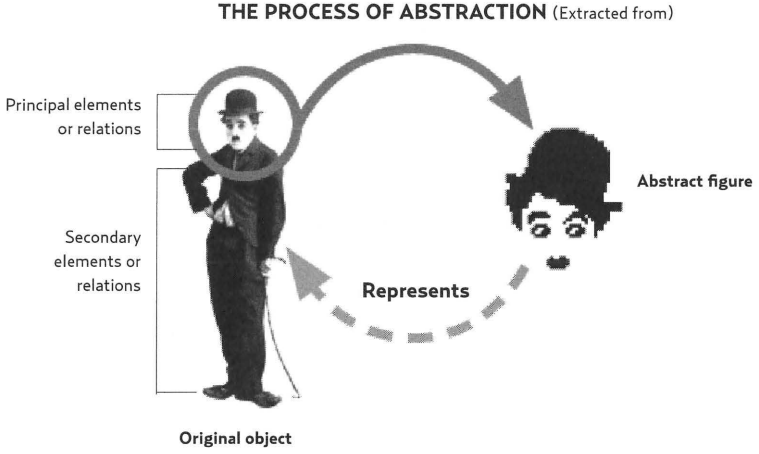


Figure 3 Art/design as an example for abstraction process model (from Hsu & Wang, 2004).

from Gombrich, 1982).

In the graphic design of traffic signs, trademarks and computer icons (*see figures* 6-8) designers convey complex ideas simply by using abstraction methods. Take Figure 6 for example, although the hands and other features are simplified, the two figures can still be identified as male and female. In Figure 7, we can only see the telephone receiver and mouthpiece, but this does not obstruct its representational meaning. In Figure 8, icons, based on visual metaphor, are used in painting software to represent the tools or actions.

In Figure 9, famous Japanese poster artist Tanaka Ikko simplifies the head of a Japanese woman, retaining very few characteristics. The lines of the ancient fish graphics in Figure 11 also use the same principles, retaining the major curvatures and linearizing and geometricizing the outlines.

DESIGN SOFTWARE REVIEW

In the digital design era, a majority of designers rely on the powerful functions of computer software to aid them in their work. Our focus is on a series of computer programs with abstraction functions, including Adobe Illustrator 10, Adobe Photoshop, Macromedia Fireworks MX and Macromedia Flash MX. Fuller descriptions will be given later. The analysis focuses on visual abstraction design. Other problems such as programming are irrelevant to the discussion of abstract design and are not considered.

Observing 'point,' 'line,' 'plane' from a design perspective

The basic visual elements of design software are points, lines and planes. Although these have proven to be appropriate in practice, they

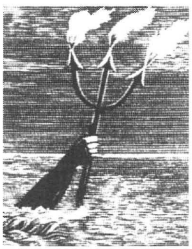


Figure 4 Trident trademark: realistic image.

Figure 5 Trident trademark: abstract image

Figure 6 Icons for male and female.

Figure 7 Icon representing a telephone.

do have some limitations in relation to the development of abstractions.
1) Point: none of the above-mentioned software enables the insertion of values to implement point simplification. The only alternative is to manually delete points by using vector illustration programs, such as Illustrator, Freehand, CorelDraw, etc.
2) Line: there are two interpretations of 'stroke' in vector software: outline and centerline. Centerline is more commonly used and is therefore the focus of the following discussions (*figure 10*).
3) Plane: adjusts the overall image's clarity and blurriness with different values, for example, the raster graphic program, Photoshop, has functions like 'mosaic' and 'Gaussian blur' under the pixelization menu.

Simplification of 'line'

There are several ways that points can be simplified. Adobe Illustrator, for example, can simplify vector images through the 'curve precision' and 'angle threshold' features. In these features, it is possible to reduce the number of points on a vector; this leads to a modified image.

Simplify path - Object/Path/ Simplify: Simplify Path

1) Percentage 0 to 100 on 'curve precision' function determines the divergence between the new paths from the old ones. When the percentage is lowered, the number of points decreases. The divergence with the original is wider and the curve is less precise, but the positions of the beginning/ ending points do not vary.
2) Table 2 demonstrates the process of the original 383-point image simplified with 'curve precision' value 100, 75, 50 25 and 0.

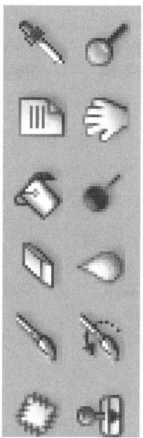


Figure 8 Computer icons.

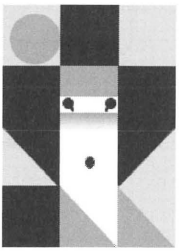


Figure 9 Poster design of Tanaka Ikko.

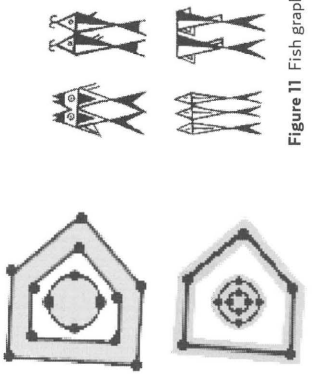


Figure 10 Two interpretations of 'stroke' in vector software.

Figure 11 Fish graphics.

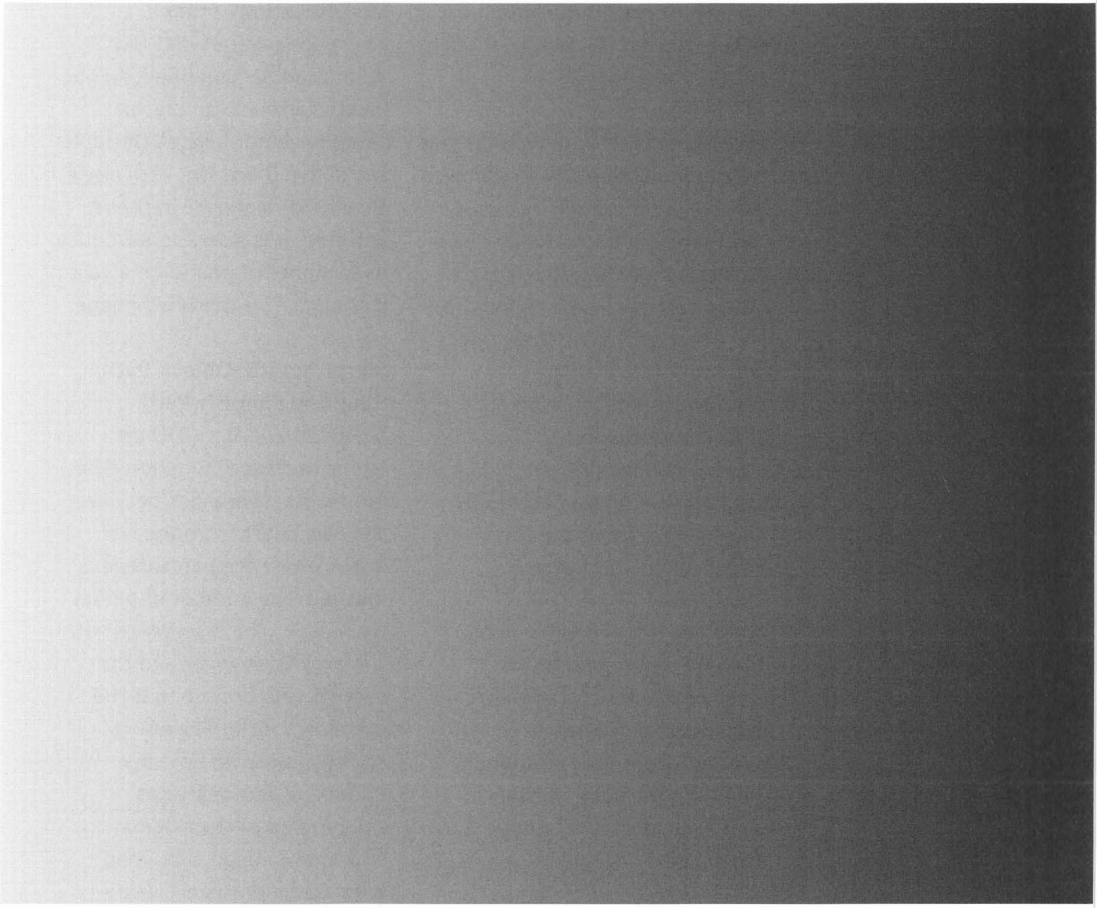
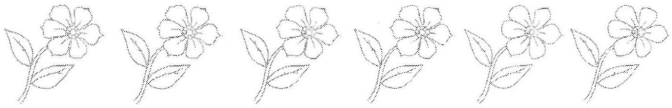
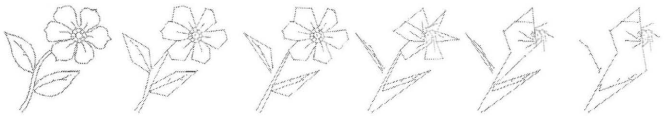


Table 2



Simplified level	**Original**	**level 1**	**level 2**	**level 3**	**level 4**	**level 4**
Curve Precision/Angle Threshold	**vector image**	**100**/180	**75**/180	**50**/180	**25**/180	**0**/180
Orginal/**Current points**	Orginal 383	383/**606**	383/**85**	383/**85**	383/**63**	383/**59**

Table 3



Simplified level	**Original**	**level 1**	**level 2**	**level 3**	**level 4**	**level 4**
Angle Threshold	**vector image**	**0**	**45**	**90**	**135**	**180**
Orginal/**Current points**	Orginal 142	142/**142**	142/**118**	142/**84**	142/**71**	142/**68**

Straight-Object/Path/Simplify: Simplify Path /straight
1) 'Angle threshold' determines the smoothness of corners. The lower the threshold value, the smoother the angle and also the fewer the number of points. When simplifying an image, increased threshold value will straighten the curve and sharpen the angle.
2) Table 3 is an example of the original 142-point image simplified with the 'angle threshold' value 0, 45, 90, 135 and 180.

Simplification of 'plane' (overall image)
'Mosaic' function of Adobe Photoshop
1) Major function: dissecting an image into grids with each grid represented by its average color to achieve the mosaic brick effect.
2) Simplification range is from cell size of 2 to 200 squares. The higher the value the greater the simplified level.
3) Table 4 divides the defaulted 2 to 200 squares into four ranks: 3, 12, 50 and 200.
4) The simplification function enlarges the pixels of the polygon. Photoshop has a comparatively smaller set of values of 'points' and 'strokes' than other vector software.
5) To reserve better 'formal/form' clues, the function is applicable to images of greater brightness or contrast.

'Gaussian blur' function of Adobe Photoshop
1) Major function: adjust the definition of 'polygon' blurring the entire image to a various extent. It gradually blurs the boundary and erases the details.
2) Simplification range is radius 0.1 to 250 pixels; the higher the value, the higher the simplified level.

Table 4

Simplified level cell size	Original Image - - -	**level 1** **3** square	**level 2** **12** square	**level 3** **50** square	**level 4** **200** square

Table 5

Simplified level radius	Original Image - - -	**level 1** **3** pixel	**level 2** **15** pixel	**level 3** **62** pixel	**level 4** **250** pixel

3) Table 5 divides the defaulted 0.1 to 250 pixels into four ranks: 3, 12, 50 and 200.

Summary

The design software reviewed explores the simplification function of software programs like Adobe Illustrator, Macromedia Flash and others. Internal commands in the software use numerical values to control the level of simplification, like the leftmost graphic of Figure 12 (original form of the flower) that has been adjusted to the simplified limit value of the rightmost graphic through the use of simplification numerical values, the changes in visual perception are not major. Correspond-

Figure 12 'Simplifying' the flower through computer-aided drawing.

Figure 13 'Simplifying' the flower through the use of hand drawings.

ingly, in terms of the graphic simplification process of the traditional drawing in Figure 13, the 'simplification' command of the software's internal key is not satisfactory. Consequently, the study hopes that the rules it presents from a design point of view can help software program designers come up with better functional components to complement the professional graphic simplification operation.

DESIGNER PRACTICE RESEARCH SECTION

To probe into the ways in which designers deal with abstract images, thirty-two sophomore and junior students with design training from the Department of Communication Design, Shih-Chien University, Taiwan were selected. Students were required to perform 'four stages' of equidistant, average simplification with a concrete image they selected. Methods and tools were not limited, but a clear demonstration of design rules and steps was required.

The result shows that the major tools used were paintbrushes (traditional hand-drawing medium) and software filters (computer media). Three abstraction methods were identified: a) shape simplification, b) quantitative reduction and c) software-aided simplification.

Method one: shape simplification method

'Simple shape drawing' is commonly introduced to children or beginners studying drawing (*see figure 14*). The point of shape simplification

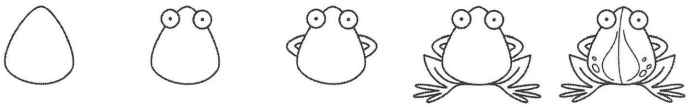


Figure 14 Simple shape drawing: introduced to children or beginners in drawing.

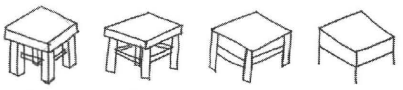


Figure 15 Simplified object: a table.

Figure 16 Simplified object: a frog.

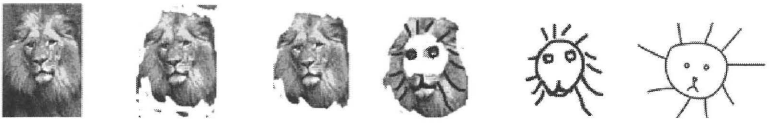


Figure 17 Simplified object: a lion.

method lies in reversing the procedure of simple shape drawing. Starting with a more complicated image, progressive deletion of strokes and lines results in a simple drawing. The final step is to outline the contours. Since the process and outcome for each student may vary, the simplification rules are not definite (*see figures 14-17*).

Method two:
quantitative reduction
According to the structure of the object, the image is dissected into individual parts. In the process of simplification, comparatively smaller blocks are removed. Compared with the 'shape simplification method' numeral reduction applies quantitative and regularization concepts in its graphic simplification (deleting smaller blocks), but graphic dissection and deletion order have not crystallized into definite rules (*see figures 18-20*).

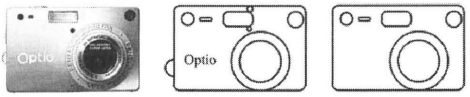


Figure 18 Simplified object: a camera.

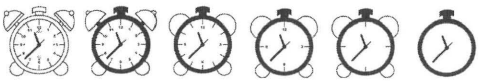


Figure 19 Simplified object: a clock.

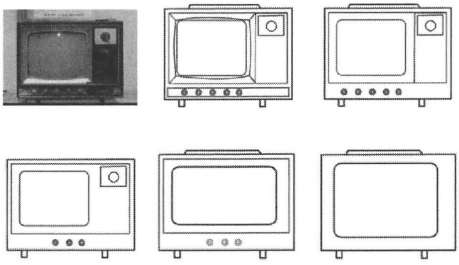


Figure 20 Simplified object: a television.

Method three: software-aided simplification

By using Adobe Photoshop functions such as 'patchwork,' 'blur' and 'mosaic' the details of an image are reduced. Only the form, color and positional relations are reserved as identifiable clues. However, when an image is overly simplified and when the form, color or positional relationship fails to be recognized, the simplification method is no longer effective. It has actually missed the essence and function of simplification (*see figures 21- 23*).

Summary

In the designer practice research section, the exercise of the thirty-two students leads to three graphic abstraction methods: shape simplification, quantitative reduction and software-aided simplification. The first method relies on intuition and experience; it does not bring about a detailed description of a simplification rule. The second method initiates a description of the rules, dividing an image into patches and achieves quantitative reduction. The third method, assisted by computer programs, can precisely control the values. Its problem parallels that of the design software research section: the simplification value of software commands does not equal a visual simplification. In addition, research discovered that students used the programs mainly for the simplification of the overall image (plane) and comparatively little for simplifying 'points' or 'lines.'

CONCLUSION

When graphic abstraction is undertaken as a purely artistic behavior, rational discussion is insignificant. In the domain of design, however, rational analysis of design method is important because of its significance in user instructions and benefits for computer-aided design.

This research investigated graphic-abstraction methods via design software research

Figure 21 Simplified object: a lion.

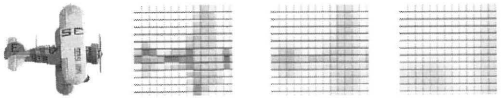


Figure 22 Simplified object: a light plane.

Figure 23 Simplified object: a helicopter.

and designer practice research. First, in design software research, although the built-in commands of design software can adjust the simplification level with its numerical functions, they can only control the value, but not the visual effect (*see figure 13*). This is a limitation of current design software. The function of simplification software was created by the programmers, but it sometimes doesn't fulfill the designers' visual requirements. It is helpful to figure out the graphic-abstraction program from the perspective of visual designers. Second, in designer practice, participants were requested to demonstrate in detail the process and methods they used while participating in an exercise about graphic abstraction. Three abstraction methods were identified:
a) shape simplification,
b) quantitative reduction and
c) software-aided simplification.

The discussion of graphic abstraction methods is important in the search for a better understanding of the rules that govern design operation. As previously mentioned, the chief meaning of method does not lie in 'innovation,' but in 'education' and 'computation.' Therefore, it may help novice designers to improve their graphic skills with some general guidelines in order to make graphic design more effective. In addition, the feasibility of each simplification rule in the application of computer-generated graphics is also worth attention through conducting experiments and assessments on their effectiveness. The authors look forward to exploring these directions in further work.

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